

MINIMUM STANDARD 3.09

**CONSTRUCTED
STORMWATER WETLAND**



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LIST OF ILLUSTRATIONS

<u>#</u>	<u>FIGURES</u>	<u>PAGE</u>
3.09-1	Constructed Stormwater Wetlands - Plan	3.09-16
3.09-2	Constructed Stormwater Wetlands - Depth Zones	3.09-16
3.09-3	Dry Weather and Wet Weather Flow Paths	3.09-17
3.09-4	Off-line Bypass Structure	3.09-18

<u>#</u>	<u>TABLES</u>	<u>PAGE</u>
3.09-1	Pollutant Removal Efficiency for Constructed Stormwater Wetlands	3.09-2
3.09-2	Recommended Allocation of Surface Area and Treatment Volume for Various Depth Zones	3.09-10
3.09-3	Clay Liner Specifications	3.09-12

MINIMUM STANDARD 3.09

CONSTRUCTED STORMWATER WETLAND

Definition

Constructed stormwater wetlands are manmade shallow pools that create growing conditions suitable for both emergent and aquatic vegetation.

Purpose

Constructed wetlands are intentionally installed on non-wetland sites to enhance the quality of stormwater runoff.

In contrast, *created wetlands* are also intentionally installed on non-wetland sites, but are designed to produce or replace natural functional wetlands and wetland habitats (e.g., for compensatory mitigation projects).

This handbook deals primarily with *constructed wetlands*. Sometimes, a constructed wetland may provide some of the benefits of a created wetland. However, understanding the differences in these two manmade systems is important. For a *natural* or *created wetland*, pre-treatment BMPs, such as erosion controls, presettling basins, biofilters, etc., are used to reduce pollutants entering the wetland to prevent its degradation and clogging. The primary function of a *constructed wetland*, on the other hand, is to provide those same types of pre-treatment functions within the wetland itself. The constructed wetland, therefore, will require maintenance to assure long-term pollutant removal. **It should be noted that the pre-treatment BMPs mentioned above will often simplify or reduce maintenance requirements, as well as enhance and prolong the useful life of a constructed stormwater wetland.**

Water Quality Enhancement

A constructed stormwater wetland can achieve high removal rates of particulate and soluble pollutants (nutrients) through gravitational settling, wetland plant uptake, absorption, physical filtration, and biological decomposition. The pollutant removal efficiency of a constructed wetland is dependent on various design criteria relating to the size and design of the pool area. Other site-specific design features and variations in environmental conditions such as soils, climate, hydrology,

etc. make it difficult to predict the actual pollutant removal efficiency. Monitoring of many stormwater wetland facilities has confirmed the wide range of pollutant removal efficiencies associated with such systems.

Constructed stormwater wetlands operate similar to retention basins, yet their overall performance is expected to be more variable. This may be due to any of the following:

1. The decrease in biological activity associated with seasonal cold weather.
2. The conversion of plant species and densities as the wetland matures and becomes acclimated to various environmental factors such as soils, hydrology, climate, and sediment and pollutant load.
3. The uncertainty of the biological cycling processes of phosphorous in the wetland environment.

The expected pollutant removal rate of constructed stormwater wetlands is provided in **Table 3.09-1**. While the rate may appear low, it reflects the uncertainty of their long-term viability.

TABLE 3.09 - 1
Pollutant Removal Efficiency for Constructed Stormwater Wetlands

Water Quality BMP	Target Phosphorus Removal Efficiency	Impervious Cover
Constructed Wetlands 2.0 x WQ Volume	30%	22 - 37%

Flood Control & Channel Erosion Control

Constructed stormwater wetlands should generally not be used for flood control or stream channel erosion control. This is due to the anticipated water level fluctuations associated with quantity controls. The clearing of vegetation and the addition of impervious surfaces may cause large and sudden surges of runoff during rain events, and may cause less than normal base flows due to lack of groundwater during dry periods. Large, sudden fluctuations in water levels can stress emergent wetland and upland edge vegetation. Most edge vegetation cannot survive drought or saturation extremes, leaving wetland banks exposed to potential erosion. It should be noted that the large surface area requirement for constructed stormwater wetlands will help to minimize the “extreme” water level fluctuations during all but the larger storm events. Also, certain plants can be specified for the upland banks which may be more tolerant to the wet and dry extremes. Therefore, preventing surges whenever possible and designing for gradual increases and decreases in water level is

important for successful constructed wetland design. See **Design Criteria** for further discussion.

(Wetland vegetation can be used to enhance the pollutant removal efficiency of extended-detention flood control and stream channel erosion control facilities by constructing a shallow marsh in their bottoms. See **Minimum Standard 3.07, Extended-Detention and Enhanced Extended-Detention Basin.**)

Conditions Where Practice Applies

Drainage Area

The drainage area criteria for a constructed stormwater wetland is similar to that of a retention basin. However, because of their shallow depth, constructed stormwater wetlands may consume two to three times the site area compared with other stormwater quality BMPs (MWWOG, 1992). Vertical (depth) storage is usually not possible in constructed wetlands due to the needs of aquatic plants. Therefore, the maximum watershed size depends on the available area on the site that is suitable for a constructed wetland system.

The minimum watershed drainage area for constructed stormwater wetlands should be 10 acres. However, this minimum should be confirmed based on the watershed's hydrology and the presence of an adequate base flow to support the selected vegetation. Similar to retention basins, a drainage area of 15 to 20 acres or the presence of a dependable base flow is most desirable to maintain a healthy wetland. A clay liner may be necessary to prevent infiltration if losses are expected to be high.

Development Conditions

Constructed stormwater wetlands are suited for both low- and high-visibility sites. However, the aesthetic problems associated with having a natural and free growing landscape feature in an otherwise manicured development setting should be avoided for high-visibility sites. Additional concerns regarding stagnation or excessive infiltration during the dry summer months may also influence the choice of location. Proper planning, design, and maintenance are critical to ensure the pollutant removal capabilities of a constructed wetland and to insure its acceptance by adjacent landowners.

Like retention basins, constructed wetlands are also suited for low- and medium-density residential or commercial developments. However, the land area required for this BMP may limit its use.

Planning Considerations

Constructed stormwater wetlands should be designed to duplicate the functions of natural wetlands, while allowing for ongoing maintenance. The designer faces the difficult task of replicating natural wetland hydrology in a constructed setting, while ensuring easy access for maintenance.

Hydrology

The hydrology of a constructed stormwater wetland is largely influenced by surface runoff. The hydrology, in turn, affects several key characteristics of a stormwater wetland, such as:

1. *Water level fluctuations.* A constructed stormwater wetland will experience rapid inundation and drawdown periods with each runoff-producing event.
2. *Permanent pool.* A natural wetland may experience seasonal standing water and/or periodic drawdowns. However, a constructed stormwater wetland is engineered to permanently hold a specific volume of water, or at a minimum, maintain pools of water of varying depths. This stored water supports the aquatic and emergent plant regime and maintains the pollutant removal efficiency of the BMP.
3. *Vegetation.* The vegetation diversity in a constructed wetland is established by the landscape plan or volunteer vegetation. The selection of vegetation should be limited to native plant species suitable for the pool depths expected within the different depth zones. Care should be taken to avoid the introduction of exotic or invasive species. The use of appropriate donor soil and wetland mulch will help prevent this problem.

In contrast, a natural wetland vegetates itself through natural selection based on the growing conditions within it. The existing source of seeds, which is usually enhanced by wildlife, allows for the constant renewal of plant life.

4. *Sediment and pollutant load.* A stormwater wetland is subject to sediment loads, especially from upland pervious areas during the first growing season. During this period, permanent vegetation in the developing watershed is still growing. Without a well-established ground cover, surface sediments can be easily transported by rainfall and resulting runoff. Accumulation of this sediment in the constructed stormwater wetland during the first growing season alone can dramatically alter the topography of the facility, affecting water levels and flow paths. Furthermore, the pollutant load (nutrients and organics) associated with urban runoff and sediments entering a constructed wetland is usually higher than that which enters a natural or undisturbed wetland in undeveloped watershed. Therefore, if the constructed wetland is used to remove pollutants, the water quality within the wetland itself will be decreased. During the planning stage of a facility, the designer should have a good understanding of site-specific runoff constituents and an understanding of their possible effects on the selected vegetation.

Site Conditions

Site conditions, such as property lines, easements, utilities, structures, etc., that may impose constraints on development should be considered when designing a constructed wetland. Local government land use and zoning ordinances may also specify certain requirements.

All facilities should be a minimum of 20 feet from any structure, property line, or vegetative buffer, and 100 feet from any septic tank/drainfield. Local landuse setbacks and other restrictions may apply.

All facilities should be a minimum of 50 feet from any steep slope (greater than 10%). Alternatively, a site-specific geotechnical report must address the potential impact of a constructed stormwater wetland that is to be installed on, or near, such a slope.

Additional considerations are as follows:

1. **Soils—**

Permeable soils are not suited for constructed stormwater wetlands. A thorough analysis of the soil strata should be conducted to verify its suitability for holding water. In the past, many BMP designs were accepted based upon soils information compiled from available data, such as SCS soil surveys. While such a source may be appropriate for a pre-engineering feasibility study, final design and acceptance **should be based on an actual subsurface analysis and permeability tests**, accompanied by appropriate engineering recommendations. Refer to the references listed at the end of **Minimum Standard 3.10, Infiltration Practices** for additional information on soil analysis techniques.

The goal of a subsurface analysis is to determine if the soils are suitable for a constructed stormwater wetland. The textural character of the soil horizons and/or strata units within the subsoil profile should be identified to at least 3 feet below the bottom of the facility. This information is used to verify the infiltration rate or permeability of the soil. For constructed stormwater wetlands, water inflow (base flow and groundwater) must be greater than water losses (infiltration and evaporation). If the infiltration rate of the soil is too great, then a constructed wetland may not be an appropriate BMP, or a liner may be required. The soil permeability may be such that the shallow depths of a constructed wetland can be maintained. However, as the depth of the permanent pool increases, the increased head or pressure on the soil may increase the infiltration rate.

For discussions regarding the appropriate soils for landscaping, see the Landscape section in this standard and **Minimum Standard 3.05, Landscaping**.

2. **Rock–**

The subsurface investigation should also identify the presence of any rock or bedrock layers. The excavation of rock to achieve the proper wetland dimensions and hydrology may be too expensive or difficult with conventional earth moving equipment. However, blasting may open seams or create cracks in the underlying rock that may result in unwanted drawdown of the permanent pool. Blasting of rock is not recommended unless a liner is used.

3. **Karst–**

In regions where Karst topography is prevalent, projects may require a thorough soils investigation and specialized design and construction techniques. Since the presence of karst may affect BMP selection, design, and cost, a site should be evaluated **during the planning phase of the project**.

4. **Existing Utilities–**

Most utility companies will not allow their underground lines and right-of-ways to be submerged under a permanent pool. If such a site must be used, the designer should obtain permission **before designing the BMP**. Note that if the utilities ever require maintenance or repair, the characteristics of the constructed wetland may be irreparably changed or damaged. The cost to move any existing utilities during initial wetland construction should be determined and included in the project's overall construction costs.

Environmental Impacts

Constructed stormwater wetlands are generally located in areas with favorable hydrology. These locations are prone to being environmentally sensitive (low-lying) as well, and may contain existing wetlands, shallow marshes, perennial streams, wildlife habitat, etc., which may be protected by state or federal laws. The owner or designer should review local wetland maps and contact local, state, and federal permitting agencies to verify the presence of wetlands, their protected status, and the suitability of the location for a constructed wetland.

With careful planning, it may be possible to incorporate wetland mitigation into a constructed stormwater wetland. This assumes that the functional value of the existing or impacted wetland can be identified and included, reconstructed, or mitigated for, in the stormwater wetland. The Virginia Department of Environmental Quality should be contacted for more information regarding wetland mitigation.

Sediment Control

A constructed stormwater wetland should not be used as a sediment control facility during site construction. A presettling basin, or forebay, may be constructed above the proposed constructed wetland facility, however, any planting or preparation of the constructed wetland site should occur after the site construction has been completed. This will eliminate any foreseeable impact from sediment loads that overwhelm temporary erosion and sediment control measures during storm events.

Maintenance

Constructed stormwater wetlands require periodic maintenance, as does any stormwater BMP. In addition, a constructed wetland will require active management of the hydrology and vegetation during the first few years or growing seasons in order for it to achieve the performance and functions for which it was designed.

Vehicular access and maneuvering room in the vicinity of a constructed wetland (and sediment forebay) is necessary to allow for long-term maintenance. In addition, the establishment of an on-site sediment disposal area, properly located and contained, will significantly reduce the cost of routine maintenance and sediment removal. Care must be taken in the disposal of sediment that may contain an accumulation of heavy metals. **Sediment testing is recommended prior to sediment removal to assure proper disposal.**

Design Criteria

This section provides minimum criteria and recommendations for the design of a constructed stormwater wetland intended to comply with the runoff quality requirements of the Virginia Stormwater Management program. It is the designer's responsibility to decide which aspects of the program apply to the particular facility being designed and if any additional design elements are required to insure the long-term functioning of the wetland.

Hydrology and Hydraulics

Chapter 4, Hydrologic Methods and **Chapter 5, Engineering Calculations** should be used to develop the post-developed hydrology of the wetland's contributing watershed, to analyze the hydraulics of the riser and barrel system (if used) and to design the emergency spillway.

The contributing watershed's area should be a minimum of 10 acres and/or there should be an adequate base flow to support the hydrology.

Embankment

The design of the earthen embankment for any impoundment BMP should comply with **Minimum Standard 3.01, Earthen Embankment**. Specific requirements for geotechnical analysis, seepage control, maximum slopes, and freeboard are particularly appropriate.

Principal Spillway

The design of the principal spillway and barrel system, or weir overflow system, anti-vortex device, and trash racks should comply with **Minimum Standard 3.02, Principal Spillway**. Weir spillways have a large cross-sectional area that can pass a considerable flow rate at low head conditions. Since reducing the depth of ponding in a constructed wetland helps to avoid stressing plant communities, an armored, weir-type spillway may be the most desirable overflow device for a constructed stormwater wetland. Further, the use of an adjustable weir will help maintain the proper water surface elevation during seasonal extremes.

Emergency Spillway

An emergency spillway that complies with **Minimum Standard 3.03, Vegetated Emergency Spillway** should be provided when possible.

Permanent Pool

Sizing a constructed stormwater wetland is based on maximizing its pollutant removal efficiency. The physical and hydraulic factors that influence the wetland's pollutant removal efficiency are the permanent pool *volume, depth, surface area, geometry, and hydraulic residence time*. Minimum design criteria are presented below for each of these factors:

1. **Volume** –

The required permanent pool volume of a constructed stormwater wetland is **2 times the water quality volume** ($2 \times \text{WQV}$). The target pollutant removal efficiency shown in **Table 3.09-1** is based on this sizing criteria.

2. **Depth** –

Four depth zones are needed within the permanent pool of a constructed stormwater wetland: a) *deep pool*, b) *low marsh*, c) *high marsh*, and d) *semi-wet* (see **Figure 3.09-2**).

- a. The *deep pool* areas of a constructed wetland should be 18 *inches* to 6 *feet* in depth and may consist of 1) *sediment forebays*, 2) *micro-pools*, and/or 3) *deep-water channels*.

1. *Sediment forebays* are highly recommended in constructed stormwater wetlands. They should be installed at stormwater inflow points to reduce the velocity of

incoming runoff and trap coarse sediments, and to spread the runoff evenly over the wetland area. The forebay should be constructed as a separate cell from the rest of the wetland and provide easy access for maintenance with heavy equipment. Refer to **Minimum Standard 3.04, Sediment Forebay** for further information.

2. *Micro-pools* offer open water areas to attract plant and wildlife diversity. If a low-flow discharge pipe is used, it should be constructed on a reverse slope and extended into the wetland below the pool surface elevation but above the bottom elevation. This helps to prevent clogging, since a typical wetland environment consists of floating plant debris and possible sediment and organic accumulation at the bottom. (Refer to the **Overflow** discussion later in this section.)
 3. *Deep-water channels* provide an opportunity to lengthen the flow path to avoid seasonal short-circuiting (see pool geometry).
- b. The *low-marsh zone* ranges in depth from 6 to 18 inches.
 - c. The *high-marsh zone* ranges in depth from 0 to 6 inches. Usually, this zone will support the greatest density and diversity of emergent plant species.
 - d. The *semi-wet zone* refers to the area that, during normal, non-rainfall periods, is above the pool, but is inundated during storm events for a period of time, depending on the amount of rainfall, and the hydraulics of the overflow device.

Note: The low-marsh, high-marsh, and semi-wet zones are useful as a perimeter shelf 10 to 15 feet wide. This shelf, or aquatic bench, can serve as a safety feature to keep children away from the open water deep pool areas. Also, as a secondary benefit, a heavily vegetated perimeter will help to discourage geese from using the facility as a permanent habitat.

The recommended surface area allocation for these depth zones is presented in **Table 3.09-2**.

3. Surface Area—

At a minimum, the pool surface area of a constructed stormwater wetland should equal 2% of the size of the contributing watershed. Recommended surface area allocations for different depth zones are shown in **Table 3.09-2** (MWCOC, 1992). Note that if the surface area criteria conflict with the volume allocations, the surface area allocations are more critical to an effective design.

4. Geometry—

The geometry of the constructed stormwater wetland must be designed to avoid short-circuiting. Maximum pollutant removal efficiency is achieved with the longest possible flow path, since this increases the contact time over the wetland area. The minimum length-to-width ratio of the pool should be 1:1 in wet weather and 2:1 during dry weather (see **Figure 3.09-3**).

TABLE 3.09-2
Recommended Allocation of Surface Area and Treatment Volume for Various Depth Zones

Depth Zone	% of Surface Area	% of Treatment Volume
<i>Deep Water</i> 1.5 to 6 feet deep	10	20
<i>Low Marsh</i> 0.5 to 1.5 feet deep	40	*
<i>High Marsh</i> 0 to 0.5 feet deep	50	*
		* combined marsh area = 80% of treatment volume

Adapted from MWCOG, 1992

The **wet weather** *length-to-width ratio* is calculated by dividing the straight line distance from the inlet to the outlet by the wetland's average width. The **dry weather** *length-to-width ratio* is calculated by dividing the dry weather flow path length by the wetland's average width. Note that the dry weather flow path is created by constructing high marsh areas perpendicular to the straight line flow path described above. These marsh areas act as submerged berms and lengthen the effective flow path.

5. Hydraulic Residence Time—

The hydraulic residence time is the permanent pool volume, divided by the average outflow discharge rate. The longer the residence time, the higher the pollutant removal efficiency (Driscoll, 1983, Kulzer, 1989).

Using $2 \times WQV$ to size the permanent pool means that smaller storms ($1 \times WQV$ or $\frac{1}{2}$ -in.) will displace only half of the pool volume of the wetland, thus providing for extended residence times. Larger treatment volumes with respect to the watershed size ($3 \times WQV$) will provide longer residence times and, therefore, greater efficiencies. In certain situations, using these larger volumes and efficiencies may be acceptable, but the decision should be made carefully. The associated challenge is to provide the recommended surface area allocations for the different depth zones as previously discussed.

Overflow

Providing flood control and/or channel erosion control within a constructed stormwater wetland creates a hydrologic regime that is very difficult to adapt to in the landscaping plan, due to extreme water depth fluctuations. If a constructed wetland is to serve as a quantity control BMP, it should

be designed to provide adequate overflow or bypass for the full range of design storms with as little vertical ponding depth as possible. The hydraulic head needed to pass a design storm is a function of the relationship between the constructed wetland surface area, the geometry of the overflow structure, and the allowable discharge (refer to **Chapter 5, Engineering Calculations**). Outlet structures should be sized to pass the design storms (up to the 10-year storm) with a maximum of 2 feet of water ponded above the wetland pool.

In a stormwater wetland designed for water quality enhancement only, a bypass or diversion structure may be used to prevent sudden surges of runoff from flushing through the wetland (see **Figure 3.09-4**). This establishes the constructed wetland as an off-line facility. If site constraints prevent the use of an off-line facility, then the overflow should be designed to pass the full range of design storms with as little head as possible. An oversized riser and barrel system or a weir structure installed along the berm at the outlet may be used. Refer to **Minimum Standard 3.02, Principal Spillway** for outlet structure design criteria.

Sediment Forebay

Sediment forebays should be installed and designed per **Minimum Standard 3.04, Sediment Forebay**. Generally, they should be constructed at the outfall of incoming storm drain pipes or channels and should be made accessible for maintenance equipment. To lower maintenance costs, an on-site disposal area should be included in the design. Sediment forebays enhance the pollutant removal efficiency of BMPs by containing incoming sediment in one area, which also simplifies monitoring and removal. Therefore, the target pollutant removal efficiency of a constructed stormwater wetland, as presented in **Table 3.09-1**, is predicated on the use of sediment forebays at all inflow points.

Liner to Prevent Infiltration

Constructed stormwater wetlands should have negligible infiltration rates through their bottom. Infiltration impairs the proper functioning of any retention facility by lowering its pool elevation. If infiltration is expected, then a retention BMP must **not** be used, **or** a liner should be installed to prevent infiltration. If a clay liner is used, the specifications provided in **Table 3.09-3** apply and the following are recommended:

1. A clay liner should have a minimum thickness of 12 inches.
2. A layer of compacted topsoil (6 to 12 inches thick, minimum) should be placed over the liner.
3. Other liners may be used if adequate documentation exists to show that the material will provide the required performance.

Safety

The side slopes of a constructed stormwater wetland should be no steeper than 3H:1V. Also, local ordinances may require fencing of deep pool areas next to the shoreline as an additional safety measure. Dense plantings of shoreline fringe vegetation can serve as a safety feature by discouraging access to the pool areas.

TABLE 3.09 - 3
Clay Liner Specifications

Property	Test Method (or equal)	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1×10^{-6}
Clay Plasticity Index	ASTM D-423 & D-424	%	Not less than 15
Liquid Limit of Clay	ASTM D-2216	%	Not less than 30
Clay Particles Passing	ASTM D-422	%	Not less than 30
Clay Compaction	ASTM D-2216	%	95% of Standard Proctor Density

Source: City of Austin, 1988

Access

A 10 to 12-foot wide access road with a maximum grade of 12% should be provided to allow vehicular access to the outlet structure area, at least one side of the basin, and the sediment forebay(s). The road's surface should be selected to support the anticipated frequency of use and vehicular load without excessive erosion or damage.

Landscaping

A qualified individual should prepare the landscape plan for a constructed stormwater wetland. Appropriate aquatic, emergent, shoreline fringe, transitional, and floodplain terrace vegetation must be selected to correspond with the expected frequency, duration, and depth of inundation.

The landscaping plan for a constructed wetland is based on the projected depth zones and onsite soil analysis, and should contain the following:

- The location, quantity, and propagation methods of plant species and grasses for the stormwater wetland and its buffer.**

The location of plants is based on the depth zones in the wetland and the inundation tolerance of the plant species. Planting zones of uniform depth should be identified for each species selected.

Only one-half of the low- and-high marsh depth zones need to be planted. If the appropriate planting depths are achieved, the entire wetland should be colonized within three years. At least 5 to 7 emergent wetland species, including a minimum of two species for each of the marsh depth zones (high and low), should be used. Selections should be based on wildlife food value, depth tolerance, price, commercial availability and/or shade limitations. Certain species, such as cattails, should be selected with caution. Although they may provide excellent pollutant removal characteristics, they can be invasive and may eventually crowd out other species.

A constructed stormwater wetland does not contain a seed bank, nor does it have an existing natural seed transport cycle as found in native wetlands. While the use of donor soil from disturbed or dredged sites may provide a seed bank, these opportunities may not be readily available. Therefore, the most common and convenient technique for establishing wetland vegetation in a constructed system is to transplant nursery-grown stock. Other propagation techniques (which are outside the scope of this manual) may also prove successful, but special growing conditions must exist.

2. Instructions for site preparation.

The soil in which the vegetation is planted should be appropriate for the wetland plants selected. Soil tests showing the adequacy of the soil, or a soil enhancement plan should be submitted with the wetland design.

The soil substrate must be soft enough to permit easy insertion of the plants. If the basin soil is compacted or vegetation has formed a dense root mat, the upper 6 inches of soil should be disked before planting. If soil is imported, it should be laid at least 4 inches deep to provide sufficient depth for plant rooting.

3. A schedule for transplanting emergent wetland stock.

The window for transplanting emergent stock extends from early April to mid-June. Dormant rhizomes can be planted in fall or winter. To insure availability, ordering stock 3 to 6 months in advance may be necessary.

4. Planting procedures.

A landscape plan should describe any special procedures for planting nursery stock. Most emergent plants may be planted in flooded or dry conditions. If planting is done in dry conditions, then instructions should be included for flooding the wetland immediately following installation.

Proper handling of nursery stock is crucial. The roots must be kept moist to prevent damage. Plants received from the nursery will be in peat pots or bare-rooted. Bare-rooted plants will have some form of protection to keep the roots moist and may be kept for several days, but out of direct sunlight. For the maximum chance of success, all nursery stock should be planted as soon as possible. A minimum acceptable success rate of the plantings should be specified in the plan.

5. **A maintenance and vegetation reinforcement schedule for the first three years after construction.**

Sometimes additional stabilization of the basin area may be necessary to ensure that the vegetation becomes established and mature prior to the erosion of the planting soil. Annual grasses may be used for this purpose. However, the specified application rates in the Virginia Erosion and Sediment Control Handbook (VESCH), 1992 edition: Temporary Seeding Spec. 3.31 should be reduced to help prevent these grasses from competing with other plants, particularly those emerging from bulbs and rhizomes. Overall, permanent seeding (VESCH Spec. 3.32) should be prohibited in zones 1 through 4, as the grasses will indefinitely compete with the wetland plants. Refer to the Maintenance and Inspection section in this standard for more information.

Additional considerations and criteria for developing a landscape plan can be found in **Minimum Standard 3.05, Landscaping**.

Buffer Zones

A minimum 20-foot wide vegetated buffer, measured from the maximum water surface elevation, should be maintained beside the wetland. Refer to **Minimum Standard 3.05, Landscaping**.

Construction Specifications

Overall, widely accepted construction standards and specifications, such as those developed by the USDA Soil Conservation Service or the U.S. Army Corps of Engineers for embankment ponds and reservoirs, should be followed to build the impoundment.

Further guidance can be found in Chapter 17 of the Soil Conservation Service's Engineering Field Manual. Specifications for the work should conform to methods and procedures specified for earthwork, concrete, reinforcing steel, pipe water gates, metal work, woodwork and masonry and any other items that apply to the site and the purpose of the structure. The specifications should also satisfy any requirements of the local government.

Guidance and construction specifications in the following minimum standards also apply for various components of the facility: **3.01, Earthen Embankment; 3.02, Principal Spillway; 3.03, Vegetated Emergency Spillway; 3.04, Sediment Forebay; and 3.05, Landscaping.**

Maintenance and Inspections

A constructed stormwater wetland may be maintained without a permit from the U. S. Army Corps of Engineers or the Virginia Department of Environmental Quality (Va. DEQ).

Any pre-treatment facility or diversion structure should be inspected and maintained regularly to remove floatables and any large debris. Sediment should be removed from the forebay every 3 to 5 years, or when 6 to 12 inches have accumulated, whichever comes first. To clean the forebay, draining or pumping and a possible temporary partial drawdown of the pool area may be required. Refer to the VESCH, 1992 edition for proper dewatering methods. A predesignated spoil area, away from the wetlands, should be used.

The constructed stormwater wetland should be inspected at least twice a year in the first three years after construction, during both the growing and non-growing seasons, for vegetative establishment. Inspectors should document plant species distribution and fatality rates and verify compliance with the landscaping specifications. Also, sediment accumulation, water elevations, and the condition of the outlet should be documented. Records should be kept to track the wetland's health over time.

Management of Wetland Vegetation

The constructed wetland and its buffer may need a *reinforcement planting* at the onset of the second growing season after construction. The size and species of plants to be used should be based on the growth and survival rate of the existing plants at the end of their first growing season. Controlling the growth of certain invasive species, such as cattail and phragmites, may also be necessary. These plants can be very hard to contain if they are allowed to spread unchecked. The best strategy may be to design for a wide range of distinct depth zones.

Research shows that for most aquatic plants the bulk of the pollutants is stored in the roots, not the stems and leaves (Lepp 1981). Therefore, harvesting before winter dieback is unnecessary. Many unanswered questions remain concerning the long-term pollutant storage capacity of plants. Additional plant maintenance recommendations may be presented in the future, as such information becomes available.

The embankment and BMP access road should be mowed biannually, at a maximum, to prevent the growth of trees. Otherwise, the buffer and upland areas should be allowed to grow in meadow conditions.

FIGURE 3.09 - 1
Constructed Stormwater Wetlands - Plan

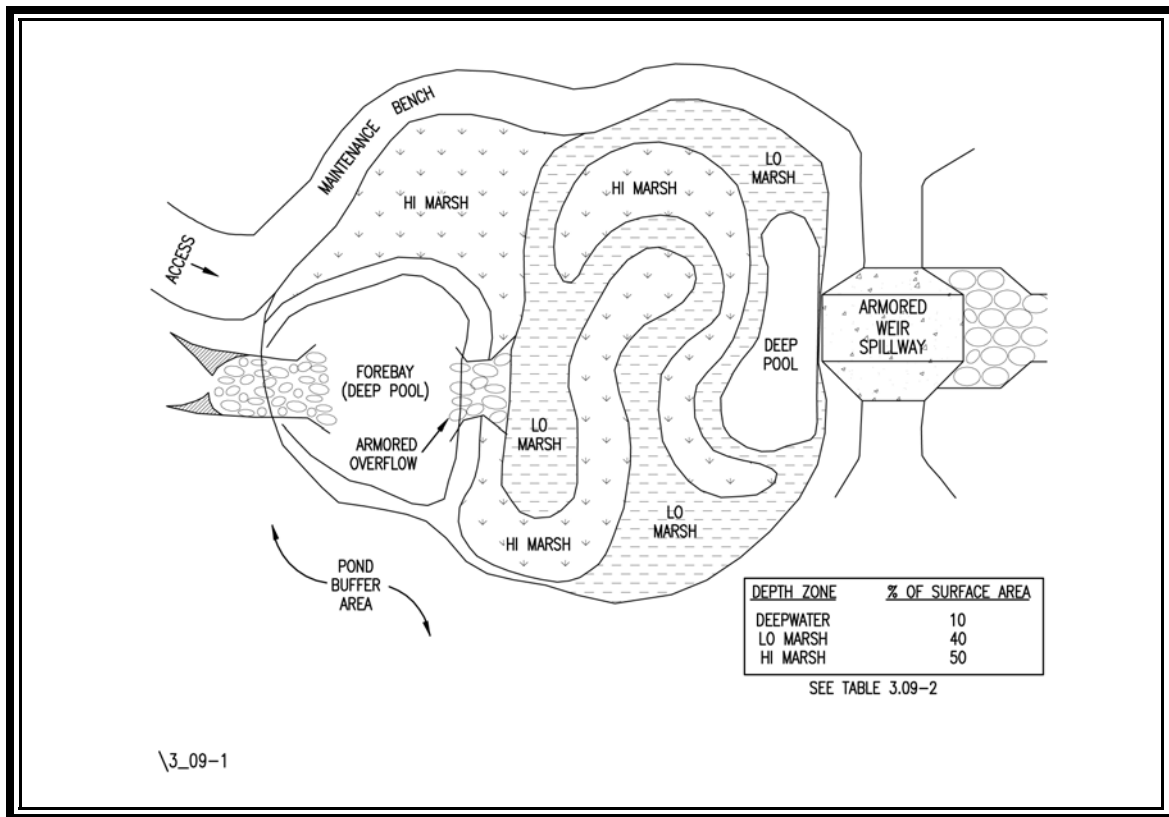


FIGURE 3.09 - 2
Constructed Stormwater Wetlands - Depth Zones

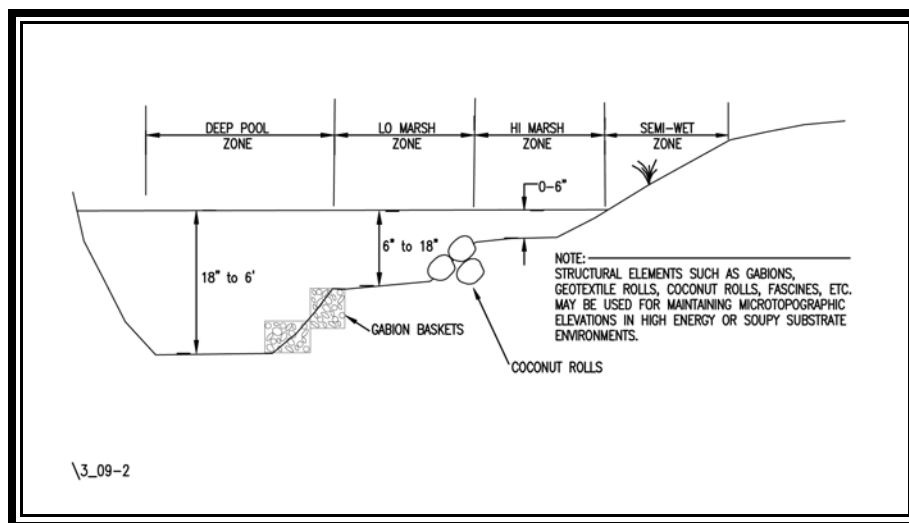


FIGURE 3.09 - 3
Dry Weather and Wet Weather Flow Paths

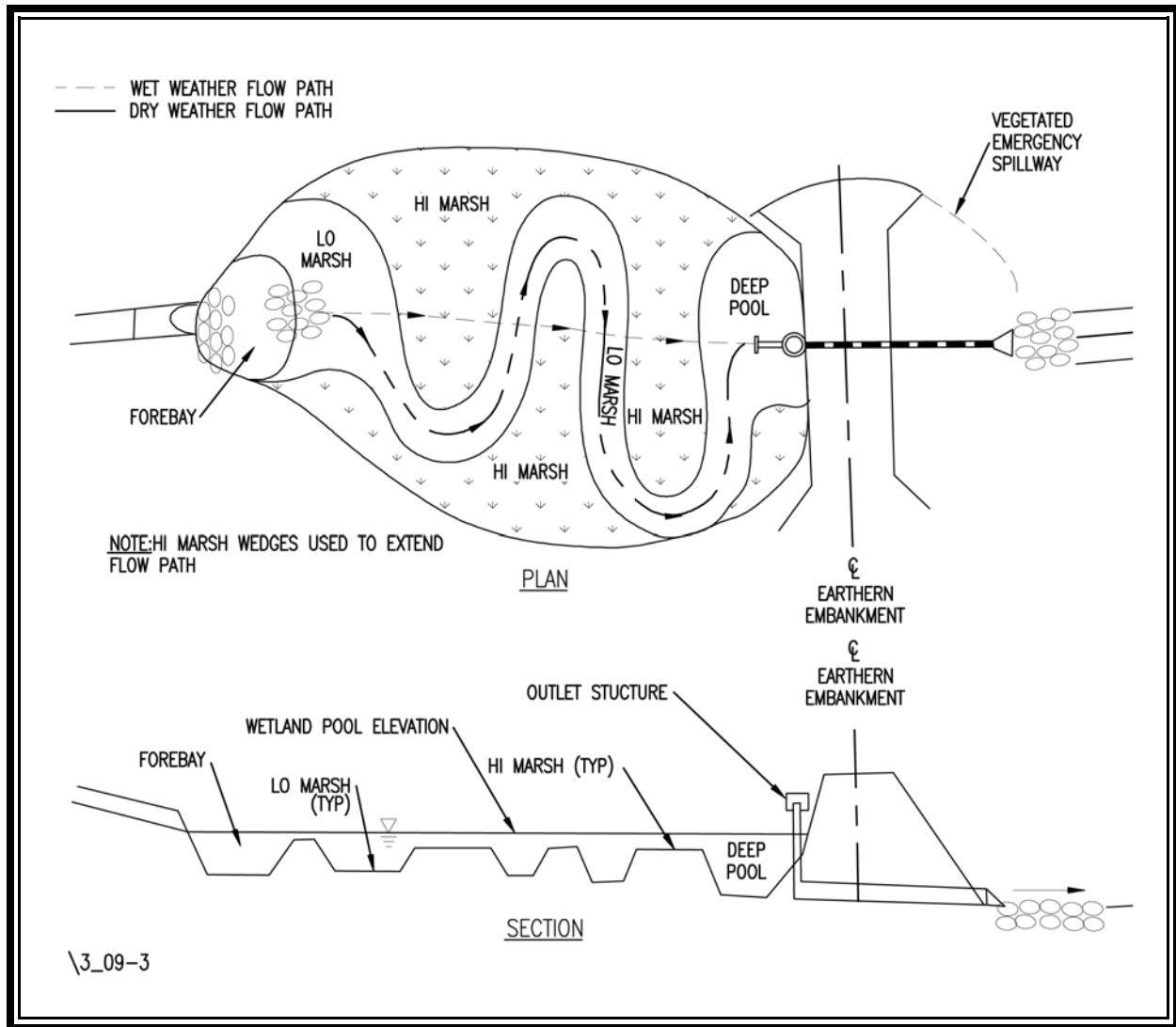
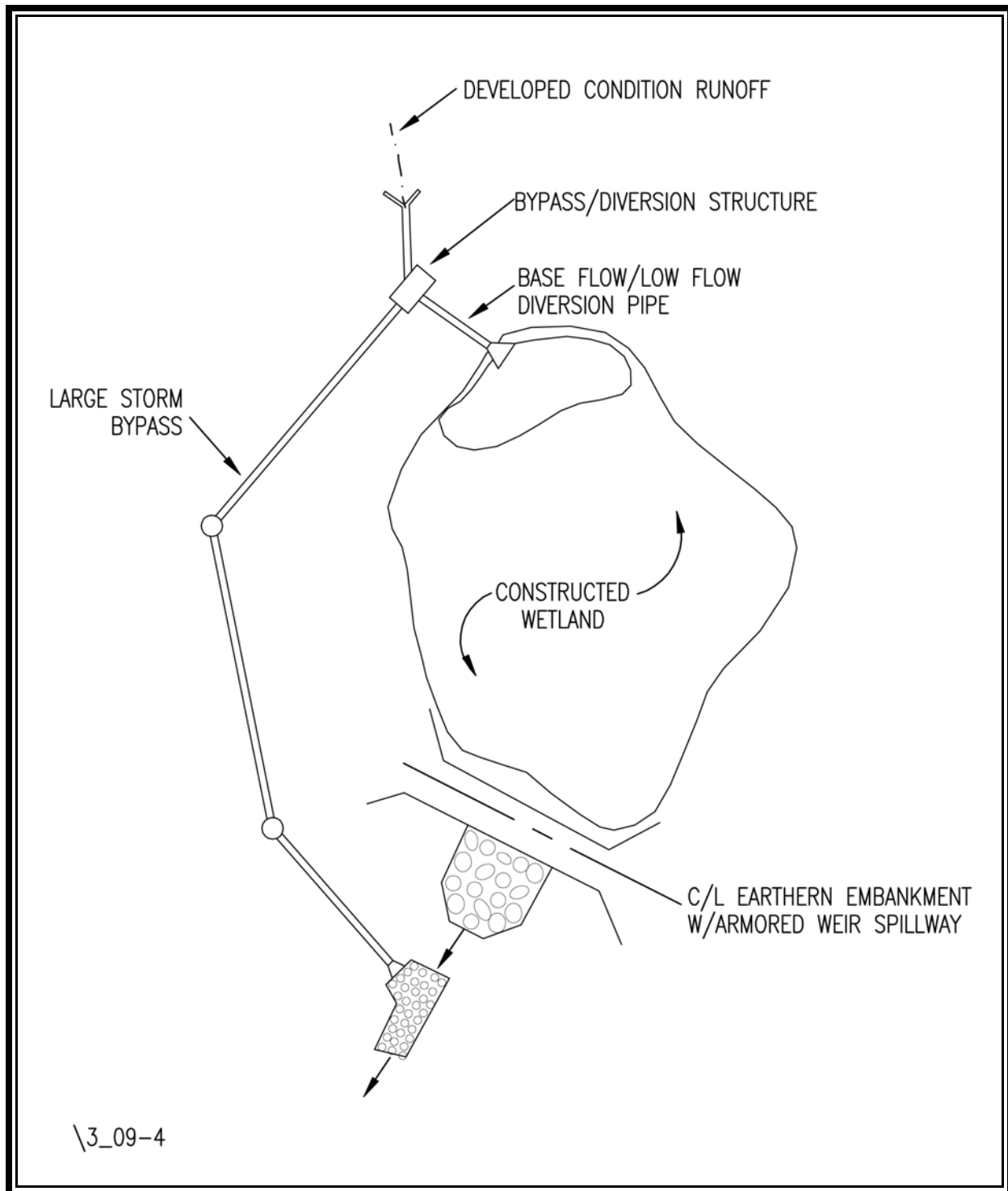


FIGURE 3.09 - 4
Off-line Bypass Structure



REFERENCES

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Constructed Stormwater Wetland – recently completed.



Constructed Stormwater Wetland – becoming stabilized, emergent vegetation barely visible.

Constructed Stormwater Wetland



Constructed Stormwater Wetland. Note vegetation protected from waterfowl by netting system.



Forebay and Constructed Stormwater Wetland incorporated into regional retention basin design.

Constructed Stormwater Wetland